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FINAL REPORT

ADDENDUM TO FINAL BACKGROUND LEVELS OF INORGANICS IN SOILS AT KELLY AFB

SAN ANTONIO AIR LOGISTICS CENTER

PARTNERS WITH THE ENVIRONMENT

ENVIRONMENTAL MANAGEMENT

Kelly Air Force Base, Texas

OCTOBER 1999

FINAL REPORT

ADDENDUM TO FINAL BACKGROUND LEVELS OF INORGANICS IN SOILS AT KELLY AFB

Prepared by Mobile District Corps of Engineers for:

Kelly Air Force Base, Texas

October 1999

Abbreviations Used in This Report

Sb	Antimony
As	Arsenic
Ba	Barium
Be	Beryllium
Cd	Cadmium
Cr	Chromium
Co	Cobalt
Cu	Copper
Pb	Lead
Mn	Manganese
Hg	Mercury
Ni	Nickel
Se	Selenium
Ag	Silver
Tl	Thallium
V	Vanadium
Zn	Zinc
Moisture	% Moisture
TOC	Total Organic Carbon
ND's	Non-detects
PQL	Practical Quantitation Limit
x~N	X distributed normally
Ln(x)	Natural log of 'x'
Ln(x)~N	Lognormally distributed
StdDev	Standard Deviation
Min(x)	Minimum 'x' value
Max(x)	Maximum 'x' value
UTL	Upper Tolerance Limit
UCL	Upper Confidence Limit
Par	Parametric
Non-par	Nonparametric
Sig	Statistically significant

CONTENTS

I. STATISTICAL ANALYSES: BACKGROUND & METHODOLOGY

1. **Background:** In 1993 soil samples were collected within the three major lithologies at Kelly Air Force Base (AFB) for the purpose of characterizing background concentrations of 17 selected inorganic constituents at the installation. In March 1994 a report of analytical results was produced. This report was reviewed in February 1999 at the request of Kelly AFB staff and was found to be deficient in its documentation and to contain statistical procedural errors as well as basic theoretical errors (See Memorandum For Record dated 23 Feb 1999 in Appendix). For example, it was not possible to determine exactly which data points were included in the calculation of summary statistics, what the sample sizes were and specifically what statistical procedures were used for each variable. It was also clear that statistical procedures were not performed in accordance with the distributional characteristics of the variables (e.g. Poisson procedure not used for Poisson variables, incorrect lognormal transformations). Given the shortcomings of the 1994 analysis, a reanalysis of the background soils data was recommended. This analysis was performed upon receiving direction from Kelly AFB and was completed in June 1999. This report presents a summary of the results of the statistical analysis of soils background data collected in 1993 for the three major lithologies within the Kelly AFB.

2. **Objective:** The primary research objective of this analysis is to re-evaluate background levels of selected inorganics in soils at the installation including development of detailed summary statistics. These values will be used for comparison to soils from base-wide areas of concern to detect the presence of contamination.

3. **Site Descriptions:** There are three primary lithologic units at Kelly AFB. They are referred to in descending order of depth as the black clay, the brown clay and the Navarro clay. The upper black clay unit where present, ranges in thickness from 0 to 7 feet and is typically a dark grayish brown silty clay. This soil type is derived from weathering of the underlying brown clay. The brown clay, which underlies the black clay, is a heterogeneous sequence of gravel, sand, silt, and clay deposited on the upper erosional surface of the Navarro clay. The brown clay comprises most of the unsaturated zone as well as the saturated zone at Kelly AFB. The thickness of this lithologic unit varies from less than 10 feet to more than 35 feet across the base. During the background study, samples of the brown clay were collected from the unsaturated zone only. The Navarro clay acts as a confining layer and prevents downward migration of contaminants present within the alluvial sediments at Kelly AFB. This unit is a hard, plastic orange-brown to blue-gray clay. The background study is concerned only with the upper surface of the Navarro clay but this unit extends to depths ranging between 440 and 800 feet below ground surface in the area of the base.

4. **Variable Descriptions:** The specific analytes tested were the same for all three groups and included 17 inorganics and two field parameters. The sample size for black clay and brown clay for each analyte was 13. For Navarro clay the sample size was 11 for all parameters. It should be noted that the cadmium values presented in the original laboratory reports (identified as NUS PKG1 & PKG2) were not used in this analysis. Cadmium was re-analyzed and presented in NUS PKG1A and PKG2A subsequent to the original laboratory analysis to attain a more

acceptable (lower) detection limit. This analysis is based on the reanalysis of cadmium. Table 1 below lists the analytes tested for the three lithologic groups.

Table 1
Soils Analytes

Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Cobalt
Copper
Lead
Manganese
Mercury
Nickel
Selenium
Silver
Thallium
Vanadium
Zinc
% Moisture
Total Organic Carbon

5. MAJOR TASKS: The following major tasks were executed in this analysis:

1) Outlier analysis to identify influential and erroneous data points.
2) Test for lithologic group differences among 3 lithologies (black, brown and Navarro clay)
3) Computation of summary statistics for each analyte for each data set to include: proportion of non-detects (ND's), identification of distribution of data, and calculation of mean, standard deviation, median, and minimum and maximum concentrations.
4) Calculation of 95% upper tolerance limits.
5) Calculation of 95% upper confidence limits.

6. STATISTICAL METHODOLOGY

6.1. Outlier Analysis: The first step in any statistical analysis is to verify the quality or validity of the data by screening the data for aberrant and/or erroneous data. Therefore, an outlier analysis was performed for each analyte in each of the three lithologic groups. Outlier analyses are statistical procedures performed to detect the presence of outliers and aberrant data prior to beginning statistical analyses. Outliers are data points that lie outside the range (either low or high) of the total sample of cases of a particular variable. That is, an outlier is identified as such because of its relative position to the remaining data in the sample, not due to its absolute value. These data values have significant impacts on calculation of summary statistics and hypothesis tests (comparison of background to site data). Some or all may actually be valid data, however each should be verified as such before any statistical analyses are performed since the presence of outliers may lead to erroneous conclusions concerning contamination at the site. Possible explanations for the presence of outliers include simple transcription errors, laboratory methods out of control, contamination of a particular sample, sampling in exclusion zones (areas not truly representative of background and affected by human activities) etc. All such errors should be either corrected or deleted from the data file. For those cases for which no explanation can be found, the data point should be treated as valid data and remain in the sample for analysis. It is not an acceptable scientific practice to delete data values simply because they are higher or lower than the others in the sample as this action introduces potentially serious bias in the statistical results obtained. The specific methods used to test for outliers are described in the Appendix (p21). In addition, copies of the data files with PQL's upon which the analyses are based are located in the Appendix (pp27-28).

6.2 Tests for Lithologic Group Differences: The Kelly AFB Background Study involved collecting metals data from 3 different lithologic groups located at the installation. It is assumed that these 3 lithologies represent 3 distinct populations of background metals. To verify this assumption statistical tests for differences among the sample means were performed. If two or more of the data sets are found to be homogeneous, a recommendation to combine data will be made.

6.3. Calculation of Summary Statistics: Summary statistics are to be calculated for each parameter in each of the three lithologic groups and in the combined groups if any are found to be homogeneous. They included sample mean, standard deviation, median, minimum and maximum values, 95% upper tolerance limit, and 95% upper confidence limit. Procedures for calculating means and standard deviations depended on the proportion of nondetects in the sample and the distributional characteristics of the variable. If nondetects constituted up to 15% of the sample, each nondetects was replaced by ½ its practical quantitation limit and statistics calculated as though there were no missing data values. When data were verified as normally distributed using the Shapiro-Wilk Test and the proportion of nondetects fell between 15-50%, either Cohen's or Atchison's adjustment method was used to estimate the mean and standard deviation after testing the assumptions of both adjustment methods to determine which was most appropriate The tests used to verify which of the two adjustment methods is appropriate are described in the Appendix (p21). If nondetects were greater than 50% of the sample, neither the mean nor standard deviation was calculated. Only the median and minimum and maximum values are displayed as representatives of central tendency and range. Similarly, for those variables that were found to be non-normal or not lognormal regardless of the proportion of nondetects, only the median, minimum and maximum values are presented. For analytes found to be lognormally distributed, an adjusted mean, standard deviation and confidence interval must be calculated as standard statistical formulas for these statistics simply using logged concentrations will not produce correct results.

The particular type of UTL and UCL calculated for each analyte also depended upon the distributional characteristics of the variable and the proportion of nondetects. A parametric UTL/UCL was calculated when approximate normality of the data was verified using the Shapiro-Wilk Test, and when the proportion of nondetects fell below 50 percent. When data dramatically departed from normality, or the percentage of nondetects exceeded 50%, a nonparametric UTL/UCL was calculated. In a nonparametric setting the UCL will actually be a bound on the median of the variable. Note that for some variables the UCL of the median may be expressed as '<x'. In this case the interval endpoint 'x' is equal to a PQL. The nonparametric UTL is equal to the maximum value in the sample. When 90 percent or more of the sample consists of non-detects, no UCL can be calculated however, a Poisson UTL can be calculated. A detailed description of the steps taken in the calculation of summary statistics is included in the appendix to this report.

6.4. Comment re: Small Sample Sizes: It is important to note that the maximum number of cases available for each analysis was at most thirteen. Concentrations of inorganics may exhibit a great deal of variability in soils for many areas in the Southwest. When there is a great deal of variability, small sample sizes result in estimates that are less precise Given the limitations of these small sample sizes, the results of these analyses should be viewed with some degree of caution. This is particularly true for the calculation of tolerance limits. Therefore, it is strongly recommended the tolerance limits be viewed within the context of the entire analysis of the variable taking into account values of all summary statistics (e.g. mean, median, minimum, maximum values etc). It is also important to point out that a small sample size significantly reduces the confidence one can place on any outlier analysis

As a final note, all analyses presented here assume all sampling and laboratory procedures were executed properly and in accordance with state and federal regulations.

6.5 Statistical Software: All statistical tests and calculations of traditional summary statistics were performed using the software package SPSS-PC Version 9.0. In addition, to accommodate procedures specified in EPA guidance which were not available within SPSS, several customized EXCEL spreadsheet programs were written and used. The SPSS program output and spreadsheet calculations are extremely voluminous (>200 pages) and are not enclosed with this report. However, copies are available upon request.

II. RESULTS OF STATISTICAL ANALYSES

1. OUTLIER ANALYSES: The following table depicts those chemical constituents of the Kelly AFB Study for which potential outliers (low and high) were detected. This table identifies all outliers and also indicates which outliers are considered 'statistically extreme' data points[1]. These values are shown with an asterisk. Information obtained in discussions with a ex-staff member of the contracting firm who performed the chemical analyses of the data verified that all errors in the data sets have been previously noted and corrected. Therefore, all identified outliers were treated as valid (useable values for this analysis). And although outside the range of the remainder of the sample, these data points were not demonstrated to be invalid and should not be deleted but remain in the data files for analyses. Note there are a number of variables for which low values as well as high values were detected. All outliers are displayed in Tables 3 with their sample ID number.

[1] Extreme outliers are values greater than 3 times the hspread (equivalent to the interquartile range) above the 75th percentile or below the 25th percentile.

Table 2
Background Soils Outlier Analyses

Black Clay			Brown Clay			Navarro Clay		
Analyte	Value(mg)	Sample ID	Analyte	Value(mg)	Sample ID	Analyte	Value(mg)	Sample ID
Sb	100% ND		Sb	100% ND		Sb	100% ND	
As	None		As	None		As	None	
Ba	160.95	BL07-U0204	Ba	89.23	BR12-U1618	Ba	159 65*	NV02-U1820
Be	None		Be	1.62*	BR12-U0810	Be	None	
Cd	None		Cd	None		Cd	0.4	NV08-U1315
Cr	None		Cr	27.93	BR12-U0810	Cr	None	
Co	2 93	BL06-U0305	Co	8.73*	BR12-U0810	Co	None	
Cu	7.15	BL06-U0305		6.61	BR04-U0810	Cu	None	
	30.22*	BL09-U0203	Cu	7.04	BR01-U0809	Pb	23 11*	NV07-U1113
Pb	38.76*	BL05-D0204		7.42	BR13-U0910	Mn	320 29	NV07-U1113
Mn	None			10.1	BR04-U0810	Hg	100% ND	
Hg	100% ND			15.34*	BR12-U0810	Ni	None	
Ni	None		Pb	None		Se	None	
Se	85% ND		Mn	615.14*	BR12-U1618	Ag	100% ND	
Ag	100%ND			504.81	BR04-U0810	Tl	100% ND	
Tl	None			438.9	BR12-U0810	V	None	
V	None		Hg	100% ND		Zn	None	
Zn	None		Ni	21.20*	BR12-U0810	Moisture	None	
Moisture	None			15.02	BR04-U0810	TOC	7320.10*	NV10-U1921
TOC	None		Se	92% ND			1664.68	NV03-U1517
			Ag	92% ND				
			Tl	92% ND				
			V	None				
			Zn	59.98*	BR12-U0810			
			Moisture	6.2	BR12-U1618			
				19.8	BR12-U0810			
			TOC	1682 69	BR04-U0810			

[1] Values displayed with an asterisk are extreme outliers.

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2. TESTS FOR LITHOLOGICAL GROUP DIFFERENCES: Tests for differences in metals concentrations between the three geologic populations were performed for each of the 19 analytes. Five of the 19 parameters were excluded from the analysis due to the high proportion of non-detects in one or more lithologic groups (Sb, Hg, Se, Ag, Tl). An analysis of variance (ANOVA) test was performed for each of the remaining 14 metals after testing the theoretical assumptions required for an ANOVA (x distributed normally and homogeneity of variance). In those instances where ANOVA assumptions were violated, the nonparametric equivalent to the ANOVA, the Kruskall-Wallis test, was performed instead. Each test was performed at the α=.05 level of significance. Statistically significant differences in background concentrations between the three lithographic groups were found in all but one of the 14 variables tested. Only As was found to be the same across all three groups. These results are depicted in Table 3 below and support the conclusion that the three lithologies are not homogeneous with respect to metals concentrations. In view of this, the data for the three different lithologies should be treated as deriving from three distinct populations and should not be aggregated. Instead summary statistics should be calculated separately for each lithology.

Table 3
Lithologic Group Comparisons: Black vs Brown vs Navarro Clay

Analyte	Result significant?	μ_{BL} vs. μ_{BR} vs. μ_{NV}[2]	Mean/Median Black Clay	Mean/Median Brown Clay	Mean/Median Navarro Clay
Sb	100% ND				
As	No				
Ba	Yes	BL>BR, BL>NV	100.22	56.86	49.53
Be	Yes	BL>BR, BL>NV	1.23	72	.67
Cd	Yes	BL>NV	.36	.30	.24
Cr	Yes	BL>BR, NV>BR	25.64	12.16	28.35
Co	Yes	BL>BR, BL>NV	6.97	4.45	4.94
Cu	Yes	BL>BR, BL>NV	14.01	8.93	6.70
Pb	Yes	BL>BR, BL>NV	12.30	7 04	5.88
Mn	Yes	BL>NV, BR>NV	370.59	302.99	141.02
Hg	100% ND				
Ni	Yes	BL>BR, BL>NV	16.05	10.47	13.80
Se	86% ND				
Ag	97% ND				
Tl	>90% ND on 2 groups				
V	Yes	BL>BR	44 72	24.76	34.60
Zn	Yes	BL>BR, NV>BR	47.56	26.98	44 04
Moisture	Yes	NV>BR	14.86	13.08	17.12
TOC	Yes	BL>BR, BL>NV	6884.06	840.91	539.57

[2] $_{BR}$ = mean metal concentration for brown clay samples; $_{BL}$= mean metal concentration for black clay; $_{NV}$ = mean metal concentration for Navarro clay.

3. SUMMARY STATISTICS: The following tables display summary statistics for each chemical constituent and field parameter in each lithologic group. Tables I, II and III in the Appendix present more detailed versions of Tables 4, 5, and 6 showing the results of tests of distributional assumptions and the specific methodology used to calculate statistics.

Table 4
Soils Summary Statistics[3]
Black Clay

Variable	%ND	#Detects	Mean	StdDev	Median	Min(x)	Max(x)	UTL	95%UCL
Sb	100.0	0	-	-	-	-	-	2 05	-
As	0.0	13	5.33	1.13	5.13	3.55	7.25	6.30	6 01
Ba	0.0	13	100.22	26.22	94.75	65.42	160.95	148.41	116 07
Be	0.0	13	1.23	0 33	1.25	0.59	1.93	1.84	1 43
Cd	69.2	4	-	-	0.38	0.26	0.43	0.43	0 39
Cr	0.0	13	25 28	9.73	25.64	14.18	48.67	43.16	31.16
Co	0.0	13	6 97	1 61	7.48	2.93	8.95	9.93	7.94
Cu	0.0	13	-	-	12.66	7.15	30.22	30.22	15.99
Pb	0.0	13	-	-	12.30	8.90	33.10	33.10	17.30
Mn	0.0	13	370.59	73.95	372.55	231.00	474.34	506.50	415.27
Hg	100.0	0	-	-	-	-	-	1.00	-
Ni	0.0	13	16.05	3 61	17.04	8.56	22.32	22.68	18 23
Se	84.6	2	-	-	0.13	0.12	0.14	1.20	-
Ag	100.0	0	-	-	-	-	-	1.15	-
Tl	23.0	10	0.29	0.12	0.32	0.24	0 50	0.51	0.35
V	0.0	13	40.30	9.04	44.72	23.45	50.84	56.91	45.77
Zn	0.0	13	47.56	13.84	52.31	23.09	65.56	73.00	55.92
Moisture	0.0	13	14 86	2 04	14.70	11 30	18.40	18 61	16.09
TOC	0.0	13	6350.89	2764 34	6884.06	2306 81	10146.56	11431.34	8021.37

[3] Sample size =13 for all parameters and all measured in mg/kg except % moisture.

Table 5
Soils Summary Statistics[4]
Brown Clay

Variable	%ND	#Detects	Mean	StdDev	Median	Min(x)	Max(x)	UTL	95%UCL
Sb	100.0	0	-	-	-	-	-	2.05	-
As	0.0	13	5.16	1.20	5.15	3.41	7.57	7.37	5.89
Ba	0.0	13	56.86	13.66	52.63	38.37	89.23	81.97	65.12
Be	0.0	13	0.72	0.28	0.69	0.32	1.62	1.23	0.89
Cd	38.5	8	0.18	0.15	0.30	0.25	0.35	0.46	0.25
Cr	0.0	13	13.39	5.83	12.16	5.86	27.93	24.10	16.92
Co	0.0	13	4.45	1.40	3.86	2.64	8.73	7.02	5.27
Cu	0.0	13	-	-	8.48	7.04	15.34	12.30	10.10
Pb	0.0	13	8.37	3.21	7.04	3.73	15.46	14.27	10.31
Mn	0.0	13	302.99	136.13	266.59	149.25	615.14	553.18	385.25
Hg	100.0	0	-	-	-	-	-	1.00	-
Ni	0.0	13	10.47	3.13	9.55	7.04	21.20	16.22	12.30
Se	92.3	1	-	-	-	0.28	0.28	1.50	-
Ag	92.3	1	-	-	-	0.23	0.23	1.15	-
Tl	92.3	1	-	-	-	0.37	0.37	1.20	-
V	0.0	13	26.38	8.16	24.76	17.82	41.77	41.38	31.31
Zn	0.0	13	26.98	12.17	25.03	12.05	59.98	49.35	34.33
Moisture	0.0	13	13.08	3.24	12.70	6.20	19.80	19.03	15.04
TOC	0.0	13	878.05	380.39	840.91	378.87	1682.69	1577.15	1107.92

[4] Sample size =13 for all parameters and all measured in mg/kg except % moisture.

Table 6
Soils Summary Statistics[5]
Navarro Clay

Variable	%ND	#Detects	Mean	StdDev	Median	Min(x)	Max(x)	UTL	95%UCL
Sb	100.0	0	-	-	-	-	-	2.15	-
As	0.0	11	6.98	4.22	5.20	2.69	15 34	14.97	9.82
Ba	0.0	11	49.85	42.32	29.74	11.76	159.65	129.94	89.96
Be	0.0	11	0.67	0.34	0.49	0.24	1.24	1.31	0.90
Cd	45.5	6	0.16	0.12	0.23	0.16	0.40	0.39	0.23
Cr	0.0	11	28.39	17.24	28.35	4.89	51 84	61.02	39.97
Co	0.0	11	4.94	2.68	3.72	1.88	9 07	10.01	6.74
Cu	0.0	11	6.7	2.28	6.77	3.29	11 04	11.02	8.23
Pb	0.0	11	7.33	15.88	5.88	3.58	23.11	37.38	10 43
Mn	0.0	11	141.02	75.85	134.84	43.18	320.29	284 57	191.97
Hg	100.0	0	-	-	-	-	-	1.10	-
Ni	0.0	11	13.80	7.02	11.49	4 06	27.30	27.09	18.51
Se	81.8	2	-	-	0 39	0.28	0.51	1.42	-
Ag	100.0	0	-	-	-	-	-	1.25	-
Tl	100.0	0	-	-	-	-	-	1.25	-
V	0.0	11	49.24	33.72	34.60	13.25	113.60	113.06	71.89
Zn	0.0	11	44.04	14.40	44.36	21.24	67.20	71.29	53.72
Moisture	0.0	11	17.12	1.79	17.30	13 80	19.40	20.51	18.32
TOC	0 0	11	1149.02	1723.37	539.57	88.17	7320.10	4410 62	3375 41

[5] Sample size =11 for all parameters and all measured in mg/kg except % moisture.

4. SUMMARY:

The statistical reanalysis of the Kelly background soils data has produced results that are well documented and considered to be procedurally acceptable and defensible. The results of these evaluations considered in their entirety adequately characterize the concentrations of the constituents of interest within the three major lithologies at Kelly AFB.

The outlier analysis revealed that there were data points that fell below as well as above the majority of the sample for a number of variables, i.e., there were low as well as high outliers. And the majority of outliers occurred in soil samples collected in the brown clay sites. There are relatively few outliers in either black clay or Navarro clay samples.

Tests to verify that the three lithologic groups represent three distinct populations of metals concentrations revealed there were statistically significant differences among the three groups in 13 of the 14 parameters with enough data to be compared. In most cases, levels of organics were significantly higher in the black clay group than either the brown or Navarro clay groups. Therefore, the three lithologic groups are not homogeneous with respect to inorganics concentrations and it would not be appropriate to aggregate them.

As a final summary note, it is recommended to use the analysis of variance approach as an alternative to UTL's alone to accomplish future site comparisons to background data. An analysis of variance compares the mean of the background analyte to the mean of the site data. This approach does not allow for a remediation decision concerning any one entire area to be based upon any singular data point but is instead an aggregate approach. Thus the decision process is based on a calculated value that is 'typical' or most adequately represents all the soils in the area being evaluated for remediation. In addition, as in any statistical analysis, any given statistic for a particular analyte should be considered within the context of the entire analysis i.e., evaluate each analyte by reviewing all summary statistics (measures of central tendency, variability, distributional characteristics, etc.) and not focussing on any single summary statistic. A final reason for a thorough consideration of the entirety of the analyses is the relatively small sample sizes of the background data groups.

APPENDIX

Memorandum For Record 23 February 1999

Subject: Review of Kelly AFB Background Soils Report (March 1994)

1. The subject report entitled 'Final Background Levels of Inorganics in Soils at Kelly Air Force Base', March 1994 was reviewed for statistical accuracy. Mr. Ken Kebbell of Tulsa District Corps of Engineers requested this review on 22 February 1999. This evaluation includes document–specific comments, followed by general comments, conclusions and recommendations.

2. The following are document-specific comments. Each comment is preceded by the location of the portion of the report to which the comment refers:

2.1. pES-1,par2: The report states "The majority of the calculated background values were determined using a 95% upper tolerance limit". This implies in some cases, a different approach (confidence limit, etc.) was used. This does not appear to be the case. The sentence should read the tolerance limit approach was applied to evaluate all data at all sites.

2.2. pES-1,par2: Table 1 should be labeled 'Upper Tolerance Limits for Metals in Background Soils' as this is what is displayed in this table. The reader is not certain of this until reading into the report and comparing these values with other tables

2.3. p2-3, par1: The report states "If the normality test indicated any of the data points had outliers, then that location would be removed from the data set". The presence of outliers should be determined primarily by looking at Box-Whisker and Stem and Leaf plots, and case listings supplemented with normal probability plots. A second very important point is that it is never acceptable to delete outliers simply because they are outliers. A fundamental rule in applied statistics is that unless you can justify deleting a case by demonstrating it is invalid or in error (e.g. it is verified to be a lab error), you never delete it. This is increasingly important when dealing with small sample sizes.

2.4.. p3-2: Reference is made to Zones 1,2 and 3. Reader should be directed to maps in appendix and informed of relevance of zone delineation to this analysis, if any. Additionally, a more detailed site description (# acres per lithological group, etc.) should be provided here.

2.5. p4-1, par1: It is stated that "As expected," the black and brown clay have similar concentrations of inorganics. If this was the expectation, the population should be considered one and the same and there is no reason to view these subgroups as distinct populations. If researchers are not sure if the groups are homogenous, they should have tested for statistically significant group differences in inorganic concentrations. If no differences were found, the two (or three) groups should be combined and treated as one homogeneous population for purposes of characterizing metals concentrations. This would have the added benefit of increasing the sample size and lend a higher level of precision to estimates of population parameters and tolerance limits.

2.6. p4-1, par2: It is not clear whether the detection limit referenced is an MDL or PQL. Also, the final sentence in this paragraph makes no sense – needs clarification.

2.7. p4-1, par3. It should be stated the lab rejects were deleted from the data file resulting in a reduction of the sample size for Sb and Se. State what final sample sizes were after deleting these cases for each group.

2.8. p5-2: This page describes the procedure used to calculate UTL's. It is not accurate. Paragraph 1 should state that if data cannot be normalized, regardless of the percentage of non-detects, a nonparametric UTL must be calculated. Par2 states Cohen's adjustment should be used when non-detects are between 15-50%. The prescribed procedure is to use either Cohen's or Atchison's adjustment after testing for which of these adjustment methods is most appropriate. They each operate under different statistical assumptions. Cohen's assumes the non-detects are actually nonzero values that are simply censored at the detection limit. Whereas, Atchison's assumes the nondetects are actually zero values. Obviously, these assumptions will affect the adjustments made to the mean and standard deviation. These assumptions must be tested and the appropriate choice made between the two. And finally, the description omits the rule for handling >90% non-detects. In this case, you may only calculate a Poisson tolerance limit. Such is the case for Hg in all three groups. Therefore, the UTL's for Hg are incorrect.

2.9. p5-3: It is clear that none of the normality tests were performed using a standard statistical software program. Beside the inherent pitfalls of possible human error in these calculations, no p-values are provided so the reader can assess the statistical significance of the tests. One should also provide the alpha level used in the tests.

2.10. P5-5: Paragraph 5.6 is very troubling, as it is scientifically questionable in a very basic sense. It is stated that additional Ba, Cr & V samples were added from the BHA to the Navarro Clay group to "ensure normality". One cannot add data to force a population to fit the preferred distribution. Either it does or does not. Also, more importantly, one may add data if and only if, the data can be ascertained to be homogeneous with respect to the population to which the data is being added. The purpose for doing so should only be to increase the amount of information (evidence) concerning inorganics concentrations. If it is determined the data is homogeneous, all inorganics data from the BHA should be added in – not just selected variables. Finally, the resulting sample size after adding cases is not provided.

3. General comments follow:

3.1. Whether the sampling procedure was random and how it was performed is not described in the report. Was sampling randomized by using a numbered grid with a random number generator? If not how was randomization ensured?

3.2. The sample sizes for each analyte for each site cannot be determined nor can statistics be checked for accuracy. It is stated n=10 for each site. Tables in one of the appendices display 13 cases for black and brown clay with a handwritten note on Table 2A pointing to duplicates (no such note on Table 3A). The Navarro clay group appears to contain 11 cases. Where are the

BHA cases and how many are there? Duplicates and rejects, while appropriately shown on a lab report, should not be displayed at all in a statistical summary. Given the above, it is impossible to determine if the percentage of non-detects and all other statistics are calculated properly.

3.3. The report is very difficult to follow. References to other portions of document are not complete or are missing.

3.4. A number of tables are illegible, as the font is too small. Additionally, many tables contain repetitive information.

3.5. Since this is a background characterization and resulting statistics presumably will be used for comparison to site values in the future, it is desirable to have a fairly high level of confidence in the background values. Assuming there are indeed three distinct populations at the installation, it is uncertain a sample of size 10 represents an adequate design to produce reliable and accurate tolerance limits for inorganics at Kelly AFB.

4. In conclusion, given the very serious scientific and methodological deficiencies and inaccuracies in this report the following actions are recommended:

4.1. Verify cases for each lithological group (which cases should be included and excluded) and properly handle the issue of adding BHA cases (include all variables if determined to be homogeneous).

4.2. Test for lithological group differences. If differences are not found to statistically significant, then combine cases, which will enhance the adequacy of the experimental design.

4.3. Recalculate summary statistics (mean, standard deviation, and UTL's). Also present range, minimum and maximum values, and median values when means not appropriate.

4 4. Reformat report into a document that is more useful to managers (include proper references & legible summary tables).

4.5. Use one of the standard, widely accepted statistical software packages such as SPSS or SAS to perform all statistical analyses. Report alpha levels and/or p-values.

5. The above recommended actions will not be difficult and can be accomplished in a very short time frame (approximately 3 weeks to produce report of results). If you have any questions concerning the contents of this memorandum please feel free to contact me at (334) 694-3848.

/s/
Linda K. Peterson
Statistician,
Mobile District
Corps of Engineers

Calculation of Summary Statistics

The required steps in the calculation of summary statistics are based on widely accepted professional standards in statistics and EPA guidance on statistical treatment of hazardous and toxic waste data.[6] These steps must be followed for each variable (analyte) in the analysis and are set forth in the following:

1. Outlier analysis: Performed to detect presence of outliers and aberrant data prior to beginning statistical analyses. Outliers are extreme data points that lie outside the range of the total sample of cases of a particular variable x. These data values have significant impacts on calculation of summary statistics and hypothesis tests (comparison of background to site data). Methods used to test for outliers should include:
   1) Stem & Leaf plots
   2) Box-Whisker plots
   3) Case listings
   4) Cumulative normal probability plots.

2. Calculate percentage of non-detects (ND's) for each x.

3. Test distribution of x for normality (x~N?) using:
   1) Shapiro-Wilks Test
   2) Normal Probability plots.

4. Calculate median, minimum(x) and maximum(x).

5. If x~N, and %ND=0, calculate mean, standard deviation and 95% confidence limits on the mean using standard formulas for the arithmetic mean, sample standard deviation and confidence intervals.

6. Handling ND's:

   1) If ND's ≤ 15% → Replace ND's with .5(PQL).
   2) For ANOVA procedures: If ND>15%, use nonparametric procedures.
   2.1) If 15%<ND's< 50% → Use Cohen's/Atchison's adjustment to calculate mean, standard deviation and confidence limits (See step 7) or tolerance/prediction limits.
   3) If 50% ≤ ND's ≤ 90% → Calculate nonparametric intervals, (report minimum, maximum and median values & calculate confidence interval on median).

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[6] *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities,* Interim Final Guidance (1989) and Addendum (1992).

4) If ND's > 90% Calculate Poisson tolerance/prediction limits.

7. Selecting between Cohen's and Atchison's adjustment methods[7]:

1) For each variable x: let n= total sample size, d= #detects's.
2) Define variable *sortd_x* = array of x (including ND's) from low to high. (Sort each var in EXCEL, copy to SPSS)
3) Define variable *cens_i* = (integer i)=1,2,...n for 'censored data' plots and statistics (including ND's).
4) Calculate inverse cumulative probabilities
cens_pr = *cens_i*/(n+1).
5) Derive corresponding standard normal z scores: *cens_z* using cumulative normal probabilities table or in SPSS using the IDF.NORMAL function.
6) Plot *sortd_x* (excluding ND's) with *cens_z*.
7) Define *det_i* = integer i=1,2...d for 'detects only' plots and statistics.
8) Calculate inverse cumulative probabilities
det_pr = *det_i*/d+1
9) Derive corresponding standard normal z scores: *det_z* using cumulative normal probabilities table or in SPSS using the IDF.NORMAL function.
10) Plot *sortd_x* (excluding ND's) with *det_z*.
11) If censored plot clearly more linear than detects-only plot use Cohen's, else use Atchison's.
12) If plots uncertain, (often the case) calculate correlation coefficients ρ*_cens*= Corr(*cens_z*,*sorted_x*) and
ρ*_det*=Corr(*det_z*,*sorted_x*). If ρ*_cens* > ρ*_det*, use Cohen's, else use Atchison's.

Note: Cohen's method requires the calculation of intermediate statistic γ then obtain λ from Cohen's statistical tables (TableA-10, Addendum). Interpolation required to derive these values which are then input into formulas for calculating adjusted means and standard deviations.

8. If x distributed non-normally calculate Ln(x).

9. Test Ln(x) for normality (see step 3).

10a If Ln(x) non-normal, try alternate mathematical transformations. If alternate transformations still non-normal use non-parametric techniques only. Report median values, min(x) and max(x). Calculate confidence intervals on median.

10b. If Ln(x) normal:

[7] Note: Both methods assume normally distributed data so, perform adjustments on transformed data (Ln(x) etc) if x not ~N.

1) Calculate $\bar{x}(Ln(X))$ and $s^2(Ln(x))$.
2) If ND's present go to step 6.
3) Input values of $\bar{x}$ and s^2 into conversion formulas[8] to calculate lognormal means, standard deviations and confidence limits so statistics will be expressed in original units of measurement. Formulas for lognormal confidence limits require use of Land's Tables of H_α and $H_{1-\alpha}$. Tables are entered with n = sample size & lognormal standard deviation. Interpolation is required to derive H values since H values are only available for limited number of sample sizes. Note: the issue of the correct value of n to use when ND's are present is presently unresolved in the statistics community. Use of n = total sample size suggested by Curt Cameron, author of EPA statistical guidance[9].

[8] Richard O. Gilbert, 1987, Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.
[9] Phone conference between Kirk Cameron and Linda Peterson, COE on 5/4/98

TABLE I: Summary Statistics Details
Black Clay

Summary Stats: Kelly AFB BG Soils - Black Clay, Yr: 1993												
Variable	%ND	#Detects	x~N	Ln(x)~N	Mean	StdDev	Median	Min(x)	Max(x)	UTL	95%UCL	Methodology
Sb	100.0	0	-	-	-	-	-	-	-	2 05	-	Poisson
As	0.0	13	Y	-	5 33	1 13	5.13	3 55	7 25	6 30	6 01	Par
Ba	0.0	13	Y	-	100.22	26 22	94.75	65 42	160 95	148.41	116.07	Par
Be	0.0	13	Y	-	1 23	0 33	1.25	0 59	1 93	1.84	1 43	Par
Cd	69 2	4	-	-	-	-	0 38	0 26	0.43	0.43	0 39	Non-par
Cr	0 0	13	Y	-	25 28	9 73	25 64	14 18	48.67	43 16	31 16	Par
Co	0 0	13	Y	-	6 97	1 61	7 48	2.93	8 95	9 93	7.94	Par
Cu	0 0	13	N	N	-	-	12 66	7 15	30 22	30 22	15.99	Non-par
Pb	0 0	13	N	N	-	-	12.30	8 90	33 10	33.10	17 30	Non-par
Mn	0.0	13	Y	-	370 59	73 95	372.55	231 00	474 34	506 50	415 27	Par
Hg	100.0	0	-	-	-	-	-	-	-	1 00	-	Poisson
Ni	0 0	13	Y	-	16 05	3 61	17 04	8 56	22 32	22 68	18 23	Par
Se	84 6	2	-	-	-	-	0 13	0 12	0 14	1 20	-	Poisson
Ag	100.0	0	-	-	-	-	-	-	-	1 15	-	Poisson
Tl	23.0	10	Y	-	0 29	0 12	0 32	0.24	0 50	0 51	0.35	Par. Adj(x)*
V	0 0	13	Y	-	40 30	9 04	44.72	23.45	50 84	56 91	45.77	Par
Zn	0 0	13	Y	-	47.56	13.84	52.31	23 09	65.56	73.00	55.92	Par
Moisture	0 0	13	Y	-	14 86	2 04	14.70	11.30	18 40	18.61	16.09	Par
TOC	0.0	13	Y	-	6350 89	2764.34	6884.06	2306 81	10146.56	11431.34	8021.37	Par

*Cohen's Adjustment on Mean & StdDev.

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TABLE II: Summary Statistics Details
Brown Clay

Summary Stats: Site= Kelly AFB BG Soils - Brown Clay, Yr: 1993												
Variable	%ND	#Detects	x~N	Ln(x)~N	Mean	StdDev	Median	Min(x)	Max(x)	UTL	95%UCL	Methodology
Sb	100.0	0	-	-	-	-	-	-	-	2.05	-	Poisson
As	0.0	13	Y	-	5.16	1.20	5.15	3.41	7.57	7.37	5.89	Par
Ba	0.0	13	Y	-	56.86	13.66	52.63	38.37	89.23	81.97	65.12	Par
Be	0.0	13	N	Y	0.72	0.28	0.69	0.32	1.62	1.23	0.89	Par: Ln(x)
Cd	38.5	8	Y	-	0.18	0.15	0.30	0.25	0.35	0.46	0.25	Par Adj(x)*
Cr	0.0	13	Y	-	13.39	5.83	12.16	5.86	27.93	24.10	16.92	Par
Co	0.0	13	N	Y	4.45	1.40	3.86	2.64	8.73	7.02	5.27	Par: Ln(x)
Cu	0.0	13	N	N	-	-	8.48	7.04	15.34	12.30	10.10	Non-par
Pb	0.0	13	Y	-	8.37	3.21	7.04	3.73	15.46	14.27	10.31	Par
Mn	0.0	13	Y	-	302.99	136.13	266.59	149.25	615.14	553.18	385.25	Par
Hg	100.0	0	-	-	-	-	-	-	-	1.00	-	Poisson
Ni	0.0	13	N	Y	10.47	3.13	9.55	7.04	21.20	16.22	12.30	Par: Ln(x)
Se	92.3	1	-	-	-	-	-	0.28	0.28	1.50	-	Poisson
Ag	92.3	1	-	-	-	-	-	0.23	0.23	1.15	-	Poisson
Tl	92.3	1	-	-	-	-	-	0.37	0.37	1.20	-	Poisson
V	0.0	13	Y	-	26.38	8.16	24.76	17.82	41.77	41.38	31.31	Par
Zn	0.0	13	Y	-	26.98	12.17	25.03	12.05	59.98	49.35	34.33	Par
Moisture	0.0	13	Y	-	13.08	3.24	12.70	6.20	19.80	19.03	15.04	Par
TOC	0.0	13	Y	-	878.05	380.39	840.91	378.87	1682.69	1577.15	1107.92	Par

*Atchison's Adjustment on Mean & StdDev

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TABLE III: Summary Statistics Details
Navarro Clay

Summary Stats: Site= Kelly AFB BG Soils - Navarro Clay, Yr: 1993												
Var	%ND	#Detects	x~N	Ln(x)~N	Mean	StdDev	Median	Min(x)	Max(x)	UTL	95%UCL	Methodology
Sb	100.0	0	-	-	-	-	-	-	-	2 15	-	Poisson
As	0.0	11	Y	-	6.98	4.22	5.20	2.69	15.34	14 97	9.82	Par
Ba	0.0	11	N	Y	49.85	42.32	29.74	11 76	159.65	129.94	89.96	Par. Ln(x)
Be	0.0	11	Y	-	0.67	0.34	0 49	0 24	1.24	1 31	0.90	Par
Cd	45.5	6	Y	-	0.16	0.12	0 23	0 16	0.40	0.39	0.23	Par: Adj(x)*
Cr	0 0	11	Y	-	28.39	17 24	28 35	4.89	51.84	61.02	39.97	Par
Co	0 0	11	Y	-	4.94	2 68	3.72	1.88	9.07	10 01	6.74	Par
Cu	0.0	11	Y	-	6.7	2.28	6 77	3.29	11 04	11 02	8.23	Par
Pb	0 0	11	N	Y	7 33	15.88	5 88	3.58	23.11	37.38	10.43	Par· Ln(x)
Mn	0 0	11	Y	-	141 02	75.85	134.84	43 18	320.29	284.57	191.97	Par
Hg	100 0	0	-	-	-	-	-	-	-	1 10	-	Poisson
Ni	0.0	11	Y	-	13 80	7.02	11 49	4 06	27.30	27 09	18 51	Par
Se	81.8	2	-	-	-	-	0.39	0 28	0.51	1 42	-	Poisson
Ag	100 0	0	-	-	-	-	-	-	-	1.25	-	Poisson
Tl	100 0	0	-	-	-	-	-	-	-	1 25	-	Poisson
V	0 0	11	Y	-	49 24	33 72	34.60	13 25	113 60	113 06	71.89	Par
Zn	0 0	11	Y	-	44 04	14.40	44.36	21.24	67.20	71 29	53 72	Par
Moisture	0 0	11	Y	-	17 12	1.79	17 30	13.80	19.40	20 51	18.32	Par
TOC	0 0	11	N	Y	1149 02	1723.37	539 57	88 17	7320.10	4410.62	3375.41	Par. Ln(x)

*Cohen's Adjustment on Mean & StdDev.

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TABLE IV

Data File 1: All Analytes except Cd[10]

Samp_Id	NUS#	Units	Grp	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Mn	Hg	Ni	Se	Ag	Tl	V	Zn	MOIST	TOC
BRO1-D0809	P0244466	mg/kg	1	<.8	5.1	51 1	0.7		15.3	3.7	8.5	6.5	266.6	<.1	10.1	<.2	<.2	< 2	28 7	27.6	12.6	435
BRO1-U0809	P0244435	mg/kg	1	<.8	3.4	45.1	0.5		8 1	3 5	7.0	7.0	224.7	<.1	7.0	.28	<.2	<.2	17.8	16.2	11.9	965
BR03-D1012	P0244433	mg/kg	1	< 8	3.5	52.6	0.6		12 2	3.9	8.4	8.2	262 0	< 1	9.4	<.5	< 2	< 2	19.9	25.0	14.5	1404
BR03-U1012	P0244430	mg/kg	1	<.8	5.2	51.8	0.6		10.2	3.4	8.7	7 0	280.2	<.1	9.7	<.5	< 2	< 2	18.4	22.6	14.7	1008
BR04-U0810	P0244432	mg/kg	1	< 8	4 6	56 7	0.7		16.2	6 6	10 1	11.3	504.8	<.1	15.0	<.2	<.2	<.2	24.8	39.2	16.8	1683
BR07-U0810	P0244441	mg/kg	1	<.8	4 3	58 5	0.7		8.9	4 7	7.6	10.5	208.0	<.1	9 5	<.1	<.2	<.2	20.1	19 8	12.0	841
BR08-U1012	P0244468	mg/kg	1	<.8	6.9	69 7	0 7		14 6	2 6	8 6	7.1	149.3	<.1	7.3	<1.0	0.23	< 2	21.0	27.3	12.9	379
BR09-U1012	P0244463	mg/kg	1	<.8	5.7	48.7	0.8		18.4	3.6	8.5	6.9	284 1	< 1	10.5	< 2	< 2	< 2	32.5	28.9	12.7	802
BR10-U1415	P0244438	mg/kg	1	< 8	5.0	38.4	0.6		10.6	4.4	8.3	5 5	304 3	< 1	10 5	<.5	< 2	<.2	27.4	19.9	10 6	783
BR11-U0709	P0244442	mg/kg	1	< 8	4 4	61 0	0 8		8.9	4.6	8.8	12.6	232.5	<.1	8.8	<.1	< 2	<.2	18.0	20.2	14 4	596
BR12-U0810	P0244462	mg/kg	1	<.8	6 0	71.9	1.6		27.9	8 7	15.3	15.5	438.9	<.1	21 2	<.2	<.2	0.37	41.8	60.0	19.8	960
BR12-U1618	P0244439	mg/kg	1	<.8	7.6	89.2	0.3		5.9	3 7	8 8	3.7	615.1	<.1	8 1	<.5	<.2	<.2	37.5	12.0	6.2	448
BR13-U0910	P0244467	mg/kg	1	<.8	5.4	44.4	0 8		17 0	4 6	7 4	7.0	168.5	<.1	9 2	<1.0	<.2	< 2	34.9	32 0	11.0	1112
BL04-U0204	P0244431	mg/kg	2	<.8	5.1	81.0	0.9		15.6	6.6	12.7	12.3	451.8	<.1	13.8	< 2	<.2	<.2	28.1	32.9	13.9	4413
BL05-U0204	P0244434	mg/kg	2	<.8	6.9	92.7	1 0		14.2	5.5	11 1	15.3	287.3	<.1	11.4	0.14	<.2	0.24	30.4	28.0	16.8	7933
BL06-U0305	P0244436	mg/kg	2	< 8	5.5	65 4	0 6		17.8	2.9	7.2	10.4	230.9	<.1	8.6	<.5	< 2	< 2	23.4	23.1	14.7	3751
BL13-U0204	P0244437	mg/kg	2	<.8	4 0	122 3	1 2		17.5	8.1	12.0	13.7	386.4	<.1	14.0	0.12	<.2	0.27	32.5	33.0	13 3	2307
BL05-D0204	P0244448	mg/kg	2	<.8	6.6	105 9	1 2		25.6	6.4	12.5	38.8	300.9	<.1	16.5	<.2	<.2	<.2	47.8	49.4	14.6	9953
BL01-U0203	P0244449	mg/kg	2	<.8	6.3	74.5	1 0		27.2	5.7	13.4	19 5	453 2	< 1	14.1	<.2	<.2	0.25	40 1	52.3	11.3	10147
BL12-U0204	P0244450	mg/kg	2	< 8	4 8	110.3	1 6		34.1	8.9	16.0	14 7	451.1	<.1	22 3	<.2	<.2	0 50	50.8	65.2	16.2	8473
BL10-U0203	P0244451	mg/kg	2	< 8	5 3	75.2	1 3		14.5	8.3	14.5	14.3	382.9	<.1	17.5	<.2	<.2	0 32	45.1	57.8	13.3	8651
BL07-U0204	P0244452	mg/kg	2	< 8	3 6	160.9	1 4		30.7	7 9	12 2	12.3	353.8	<.1	17 0	<.2	<.2	0.34	46.6	55.1	15.5	4970
BL11-U0305	P0244453	mg/kg	2	< 8	4 3	112.7	1 3		27.5	8 3	13 8	12.1	353.5	< 1	19.1	< 2	<.2	0.42	44.7	53.9	15 7	2966
BL09-U0203	P0244454	mg/kg	2	<.8	5.1	94 8	1 3		30 2	7.8	30 2	16.8	474.3	< 1	18.7	< 2	<.2	0.32	48.8	65.6	12 3	8438
BL08-U0204	P0244455	mg/kg	2	<.8	4.7	123 8	1 5		25.0	7.5	14.3	17.2	372 5	< 1	18 0	< 2	< 2	0.43	37.4	49.6	18 4	3676
BL06-D0305	P0244456	mg/kg	2	< 8	7.2	83 6	1 9		48 7	6 5	12 3	13 2	318 8	< 1	17 6	< 2	< 2	0 24	48.1	52.4	17.2	6884
NV01-U1820	P0244444	mg/kg	3	<.8	5.2	159 7	1 0		47 3	7 5	7.8	8 9	141 1	< 1	22 2	<.2	< 2	< 2	60 1	67.2	19 2	1015
NV02-D1719	P0244446	mg/kg	3	<.8	3.9	26.6	1.1		47.4	3 3	6.4	5 5	101 3	< 1	10 7	< 2	<.2	<.2	113 6	44 4	18 4	625
NV03-U1517	P0244443	mg/kg	3	< 4	15 3	20 3	0 8		51 8	3 9	7 6	5.0	110.0	<.1	15 2	< 2	< 2	< 2	94 2	51 4	15.9	1665
NV02-U1719	P0244447	mg/kg	3	<.8	2 7	29.7	0 9		42 5	2 8	5 3	5 9	54 3	<.1	10 6	<.2	<.2	<.2	78.5	35.6	18.3	441
NV04-U1820	P0244445	mg/kg	3	<.8	3.3	11 8	0.5		28 4	1 9	3 3	5.9	43.2	<.1	8.5	<.2	<.2	<.2	18.7	32 1	15.0	635
NV05-U0910	P0244422	mg/kg	3	<.8	8.2	48.8	0.3		10 1	2 2	4 3	4.6	116.0	< 1	6.4	<.2	<.2	< 2	22.5	28.4	13 8	88
NV06-U1012	P0244425	mg/kg	3	<.8	4.4	41 3	0.2		4 9	3 7	4 7	3.6	134.8	< 1	4 1	< 2	<.2	<.2	13.2	21.2	16 2	430
NV07-U1113	P0244426	mg/kg	3	< 8	13.4	67.4	0.5		9.5	7.7	7.2	23.1	320.3	< 1	11 5	< 2	<.2	< 2	34.6	36.6	18 2	440
NV08-U1315	P0244427	mg/kg	3	< 8	6 0	28 5	0 5		15.4	9 1	6 8	4.4	205 6	< 1	19.2	<.2	<.2	< 2	33 9	52.7	17.3	363
NV09-U1012	P0244428	mg/kg	3	< 8	4 6	23 3	0 4		20.7	3 7	9 4	6 0	158 3	< 1	16 2	0.28	< 2	<.2	20.4	54.4	16 6	540
NV10-U1921	P0244429	mg/kg	3	< 8	9 7	87 5	1 2		34.2	8.4	11 0	9.3	166 3	< 1	27 3	0.51	<.2	< 2	52 0	60.4	19 4	7320

[10] All values adjusted for % moisture.

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Table V
Data File 2: Cadmium (Re-analyzed)[11]

SAMP_ID	NUS#	GRP	CD UNITS
NV03-U1517	P247556	3	<0 10 mg/kg
NV01-U1820	P247557	3	<0.20 mg/kg
NV04-U1820	P247558	3	<0 08 mg/kg
NV02-D1719	P247559	3	<0 13 mg/kg
NV02-U1719	P247560	3	<0 24 mg/kg
NV05-U0910	P247536	3	24 mg/kg
NV06-U1012	P247539	3	21 mg/kg
NV07-U1113	P247540	3	24 mg/kg
NV08-U1315	P247541	3	40 mg/kg
NV09-U1012	P247542	3	.18 mg/kg
NV10-U1921	P247543	3	.16 mg/kg
BL05-D0204	P247561	2	<1.30 mg/kg
BL01-U0203	P247562	2	<0.38 mg/kg
BL12-U0204	P247563	2	<0.35 mg/kg
BL10-U0203	P247564	2	<0 30 mg/kg
BL07-U0204	P247565	2	<0 34 mg/kg
BL11-U0305	P247566	2	<0 33 mg/kg
BL09-U0203	P247567	2	<0 38 mg/kg
BL08-U0204	P247568	2	<0.34 mg/kg
BL06-D0305	P247569	2	<0 34 mg/kg
BL04-U0204	P247545	2	37 mg/kg
BL05-U0204	P247548	2	43 mg/kg
BL06-U0305	P247550	2	26 mg/kg
BL13-U0204	P247551	2	39 mg/kg
BR12-U0810	P247575	1	<0 34 mg/kg
BR09-U1012	P247576	1	<0.24 mg/kg
BR01-D0809	P247579	1	<0 33 mg/kg
BR13-U0910	P247580	1	<0 26 mg/kg
BR08-U1012	P247581	1	<0.60 mg/kg
BR03-U1012	P247544	1	27 mg/kg
BR04-U0810	P247546	1	.32 mg/kg
BR03-D1012	P247547	1	29 mg/kg
BR01-U0809	P247549	1	25 mg/kg
BR10-U1415	P247552	1	.30 mg/kg
BR12-U1618	P247553	1	30 mg/kg
BR07-U0810	P247554	1	.35 mg/kg
BR11-U0709	P247555	1	.32 mg/kg

[11] All values adjusted for % moisture.

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